Small ruminant feeding strategies in smallholder systems: a synthesis of global experiences and recommendations for Ethiopia

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Introduction

This short report contributes to the ACIAR-funded ELF Project and addresses the Project Deliverable: *"Synthesis of experiences with successful small ruminant feeding strategies from elsewhere with recommendations for how they could be modified for Ethiopia"*.

The context is the Project's aim to better understand *"how feed components of livestock production systems in Ethiopia are changing as systems intensify and how this is reflected in the feed-related elements of focal value chains"*. The implication is that the recommendations from the synthesis will serve as potential feed-based interventions for improving the livelihoods of smallholders keeping sheep and goats (small ruminants, SR) and that these interventions will contribute to the intensification of the SR production.

In this report the term "smallholder" covers the range of households depending for their core livelihood on practices that range from 'landless small-scale livestock-keeping' to 'pastoral systems that use extensive areas of common property pastures'. In rural Ethiopia, as in many tropical developing countries, the large majority of smallholder households practise small-scale crop-livestock farming in which subsistence food production is the major objective and any surpluses may be sold.

Identifying successful small ruminant feeding strategies

A three-pronged approach was taken to identify successful small ruminant feeding strategies from elsewhere that could be relevant to small ruminant production in Ethiopia:

1. the authors drew on their knowledge of current and past R&D activities and the related literature;
2. an electronic search of the global literature on small ruminant systems was carried out;
3. key informants were approached for their advice, for information about any undocumented successes and for links to the grey literature.

Given the minor roles of SR milk and fibres relative to meat production in Ethiopia, and the apparent large scope for the increased domestic and export marketing of SR meat, it was decided to focus the search for successes on smallholder SR meat production.

Broad consensus

Feedback from the key informants, persons of long experience in their regions, confirmed the authors' own view – and the results of the literature search - that while there were many well-documented theoretical options for improved feeding strategies[1], there was limited uptake (successes) in smallholder SR systems.

[1] See Appendix for selected examples.

Broadening the search beyond SR to smallholder dairy and beef fattening provides some examples of successes. However, while these were highlighted during the recent FAO electronic conference that assessed the "*Successes and failures with animal nutrition practices and technologies in developing countries"* (FAO, 2011; Owen et al, 2012), the overall conclusion from the conference was that the general lack of adoption of the many technologies and approaches considered by the review resulted from:

- the failure of scientists to involve farmers when developing new technologies;
- the failure to demonstrate convincing benefit:cost ratios; and,
- the weakness of extension services.

The conference built upon and updates the results of several reviews. These include Ben Salem and Smith's assessment of feeding strategies to increase small ruminant production in dry environments (Ben Salem and Smith, 2008) and the extensive publications by Devendra in Asia (e.g. Devendra, 2010; Devendra and Leng, 2011). Although the latter reviews highlight the success of integrating SR with plantation crops, these systems are not found, at least as yet, in Ethiopia.

It is possible that there were gaps in our literature search as a result of the often poor linkages and information flows between the research and development communities. For example, in the 2006 regional workshop "Goats – Undervalued Assets in Asia" (Gray and Wagner, 2008), it was concluded by the participants that accessing the lessons from development projects and research that often precedes new projects was difficult, and that much information remained unpublished in the files of implementing and funding agencies. However, given the scope of our key informant network and the extent of the formal publications that document apparent successes (e.g. the 2005 special edition of Tropical Grasslands Vol. 39), it seems unlikely that our search has missed significant success stories related to specific improved feeding strategies for smallholder sheep and goat production.

On the other hand what was highlighted throughout was the range of theoretical options but their lack of practical adoption, which emphasizes the need for the farmer participatory, action-research based approach described by Horne and Stür (2003) and typified by the successful adoption of planted forages in upland systems in the Philippines reported by Gabunada et al (2007). Success depended not just on the improved nutrition from planted forages but their key role in labour-saving, soil conservation and catalyzing market-oriented opportunities for the livestock keepers.

Therefore, it is our view that successful feed-based interventions will depend upon long-term inter-institutional approaches that address through participatory methods the broad basis of smallholder livelihoods (i.e. beyond but including livestock), household coping and risk management strategies and the market context of SR meat production. Targeting *successful small ruminant feeding strategies from elsewhere* and applying them within Ethiopia will require building upon and improving our current understanding of the livelihood systems of smallholders and of their farming systems and, within that livelihood and systems context, the value chains for sheep and goat meat.

Sheep and goat meat production in Ethiopia

Solomon Gizaw et al (2010) describe in detail the sheep and goat production and marketing systems in Ethiopia. Their classification for sheep production, presented in Table 1, captures the variation in agro-ecology, the main products from the systems and the scale of production and management (based on feeding, veterinary care, housing practices). Extensive/low-input production of sheep meat comes from the "Pastoral" and "Subalpine sheep–cereal" systems, while the "Highland cereal–livestock", the "Highland perennial Crop" and the "Lowland crop–livestock (agro-pastoral)" systems can be considered mainly semi-intensive, low-input production.

Table 1: Major sheep production systems in Ethiopia

Production Systems	Environment	Characteristics of production systems	
		Main products	**Scale of production and management†**
Sub-alpine sheep–cereal	Sub-alpine (>3000 m)	Meat, fibre, manure, skin; unreliable, long-season barley	Medium scale sheep production; semi-intensive/extensive, low-input
Highland cereal–livestock	Highlands (2000–3000 m)	Mainly cereal cropping; meat, manure, skin	Small-scale sheep production; semi-intensive, low-input
Highland perennial crop	Highlands (1500–2000 m)	Mainly perennial cash crops (coffee, inset, khat); meat, skin	Minor sheep production; semi-intensive, low-input; some practice tethering
Lowland crop–livestock system (agro-pastoral)	Sub-moist/ moist lowland (≤1000 m)	Cereals, sesame, cotton; meat, skin	High level of livestock keeping; extensive/semi-intensive, low-input
Pastoral	Semi-arid/arid (≤1000 m)	Meat, milk, skin; minimal or no cropping	Rangeland-based large-scale sheep production; extensive, low-input

† Based on feeding, veterinary care, housing practices.
Source: Solomon Giwaz et al. (2010) from Solomon et al. (2008).

To design specific projects and select sites representative of household populations having similar feed resource constraints, this broad classification of sheep production systems (Table 1) can be overlain on the more detailed livelihoods classification presented in the Livelihoods Atlas for Ethiopia (GoE/USAID-Ethiopia, 2011). As well as defining local livelihood zones (see, for example, page 123 for the 27 livelihood zones in the Amhara Region, three of which specifically mention sheep and goats), the Atlas provides - based on extensive, repeat household surveys - maps showing the areas in which sheep and goats cover at least 5% of annual total income requirements (page 41). As expected the major determinant of the crop-livestock-based livelihood zones are the staple cereal and root/tuber crops. Examples are: "North Shewa Highland Sheep and Barley" and "Tekeze Lowland Sorghum and Goats".

Testing successful feeding strategies in Ethiopia

While the location-specificity of feed resources, community and household resource endowments and market linkages and their utilization within livelihood zones will determine the opportunities for, and the returns to, feed-based intensification, the characteristics of the five sheep production systems (Table 1) and the related goat systems suggest some broad areas of potential intervention. These relate to farmers' current production practices and the major classes of feed resources in Ethiopia.

The principal feed resources in SR production systems are: natural grazing and browse (often as common property resources); crop residues and crop stubbles; fallow grazing; crop by-products and other concentrate feeds (e.g. brewers grains); and, planted forages (Solomon Gizaw et al, 2010). At any specific location the relative importance of each of these feed classes in supporting production will reflect current land use (public vs private; cropping vs grazing) and cropping practices (Table 1). Opportunities for, and the returns to, feed-based interventions for increasing meat production will also depend on how the flock and its age/sex classes, e.g. ewes/does and pre-slaughter animals, are managed.

Determining what intervention or interventions have potential at which location will require applying to each value chain and location participatory methods and tools such as those being refined in the current ELF project: VCA (value chain assessment), FEAST (feed assessment tool) and Techfit (technology prioritization). The analysis should be capable of showing whether there is potential for feed-based interventions to improve, for example, the performance of breeding females. The expected return will be improved survival rates at birth and higher live weights of weaned lambs/kids produced per ewe or doe per year. On the other hand – or in addition - a promising entry-point is the better feeding of slaughter stock prior to their sale to increase profit. While other production cycle entry-points may have potential, within current SR systems in Ethiopia these two – improving the performance of breeding females and of fattening/finishing, and especially the latter - seem most promising.

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There are various feeding strategies that have been demonstrated elsewhere and/or in Ethiopia for achieving this improved performance.

Common property resources (CPR): These remain important feed resources for significant proportions of Ethiopia's sheep and goat populations and improving the biomass production of degraded CPR can increase overall flock performance and conserved forage can be targeted at specific production objectives, e.g. fattening. In western India, propagated through BAIF and other NGOs, increased fodder and fuel availability has been achieved through introducing village committees to manage degraded CPR and develop silvi-pastures (Rangnekar, pers. comm.). In Ethiopia a similar approach to regenerating CPR has been successful in increasing fodder availability through community-based management in the Atsbi benchmark site of the IPMS project (ref?).

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In some of Ethiopia's CPR zones that are prone to drought and salinity some halophytes, for example *Atriplex*, may be a promising intervention. Various species belong to the Atriplex family and are distinguishable by their different morphology, biological cycle and ecological adaptations (Le Houerou, 1992). Because of their high crude protein content, and tolerance to drought and salinity, most species of Atriplex are excellent livestock fodder in arid and semi-arid areas. *Atriplex halimus, Atriplex lentiformis and Atriplex nummularia* are examples. The Box summarizes experiences using Atriplex for small ruminants in Tunisia and Morocco ((Shideed et. al, 2005).

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The impact of NRM research in crop/livestock production systems in arid and semi-arid areas of Morocco and Tunisia was assessed. Results indicate that *Atriplex* alley cropping (with barley) technology is adopted by 33% of farmers in the targeted community in Morocco, with nearly 24% of the land is planted in alley cropping. On average, adopters assigned nearly 27% of their farmland to *Atriplex* alley cropping but this varied considerably across farms. Overall, the area planted to *Atriplex* has increased by 6% annually since 1999. Farm size, compensation provided by a development project, and flock size of small ruminants are the main factors explaining the expansion in the *Atriplex* plantation. Area in alley cropping increases with the increases in farm size, flock size, and the availability of the subsidy. The ex-post impact of the alley cropping on barley production is to increase barley grain yield by 17% compared to barley/fallow system. The technology has contributed to the increase in flock size of small ruminants between 2001 and 2004 by 25% among technology adopters compared to non-adopters due to the increase in feed supply. Likewise, the adoption of this technology has resulted in changes in the consumption and mix of alternative feed resources, and consequently of feeding cost. On average, the feeding cost of small ruminants has decreased by 33% due to the adoption of the *Atriplex* technology. This cost reduction is due to the substitution of costly and purchased feed resources, such as wheat bran and sugar-beet pulp, by *Atriplex* biomass and barley straw. To estimate the impact of alley cropping, the IRR was estimated for the 1992-2015 period, taking into account research and extension costs, as well as the subsidy provided by the development project, and all other costs. The estimated IRR is 29%. Results support the economic feasibility of research investment in Atriplex technology. ¶

Atriplex spp for small ruminants in Tunisia and Morocco

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Atriplex (saltbush) is a fodder shrub well adapted to dryland climates and soils. It is a useful protein supplement. Additional benefits of *Atriplex* include provision of fuelwood and control of soil erosion. The impact of introducing *Atriplex* as an alley crop with barley in crop/livestock production systems in arid and semi-arid areas of Morocco and Tunisia by ICARDA between 1999 and 2005 was assessed. Results indicated that *Atriplex* alley cropping (with barley) technology was adopted by 33% of farmers in the targeted community in Morocco, with nearly 24% of the land planted in alley cropping. On average, adopters assigned nearly 27% of their farmland to *Atriplex* alley cropping but this varied considerably across farms. Overall, the area planted increased by 6% annually since 1999. Farm size, compensation provided by a development project, and flock size of small ruminants were the main factors explaining the expansion in the *Atriplex* plantations. Area in alley cropping increased with the increases in farm size, flock size, and the availability of the subsidy. The ex-post impact of the alley cropping on barley production is to increase barley grain yield by 17% compared to barley/fallow system. The technology contributed to the increase in flock size of small ruminants by 25% among technology adopters compared to non-adopters due to the increase in feed supply. Likewise, the adoption of this technology resulted in changes in the consumption and mix of alternative feed resources, and consequently of feeding cost. On average, the feeding cost of small ruminants decreased by 33% due to the adoption of the *Atriplex* technology. This cost reduction was due to the substitution of costly and purchased feed resources, such as wheat bran and sugar-beet pulp, by *Atriplex* biomass and barley straw. To estimate the impact of alley cropping, the Internal Rate of Return (IRR) was estimated for the 1992-2015 period, taking into account research and extension costs, as well as the subsidy provided by the development project, and all other costs. The estimated IRR was 29%. Results support the economic feasibility of research investment in Atriplex technology. This technology has been sustained in Tunisia and Morocco as a result of the incorporation of the establishment and management of the *Atriplex* shrubs into their National Strategies for rangeland rehabilitation.

Improving the quantity and quality of crop residues: In Ethiopia's agro-pastoral and crop-livestock systems (Table 1) the area for crop production is increasing and grazing areas are being reduced (Yayneshet, 2010; Firew et al, 2010). Increasingly, therefore, crop residues form a major portion of the diets of large and small ruminants. Improving these cereal and grain legume residues through selecting varieties that yield more total biomass with better quality is a promising approach being applied to sorghum and other cereal crops in India (Blummel, 2010). In West Africa improved dual-purpose cowpeas (Tarawali et al, 2005) and in India groundnuts (Teufel et al., 2011) have improved the feed resource base for large and small ruminants. Gender-differentiated decision-making

may well play an important part in adoption decisions (Saghir et al., 2012) and should be integral to the participatory approach to identifying and testing promising technologies.

Exploring these opportunities for improvements in total yield (human food, crop by-products and residues) through food-feed crop selection within the major cereal and grain legume crops in Ethiopia should be an important component of national efforts to achieve better feeding for meat production from small and large ruminants. Along with any genetic improvement of the food-feed crops it is expected that population pressure and market forces will lead to increased fertilizer use and to other agronomic practices that will contribute significantly to increased crop biomass yields per ha and per unit of labour.

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To be successful the genetic improvement of staple cereal and root/tuber crops and grain legumes for food-feed characteristics and increasing biomass yields of these improved crops through agronomic practices (especially fertilizer use) will require substantial investment in systematic R&D. Gaining support for this will require field-based evidence to substantiate the expectation of significant returns through increased crop and livestock productivity and smallholder livelihoods. *Any relevant references for maize in Ethiopia perhaps from the BMZ-funded project*?

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Utilization of Sesbania in smallholder farmers in the Ethiopian Highlands depends on the farming system

Sesbania sesban is one of the exotic multipurpose fodder trees introduced in the Ethiopian highlands for livestock feed and soil conservation. Sesbania supplementation is appreciated across annual (wheat-based, teff-based) and perennial (coffee-based) livestock systems for its feeding value for sheep. With an average of 6.9 years of experience using sesbania as a cut-and-carry supplementary feed, sheep farmers in the highlands who were interviewed perceived feeding of sesbania to result in increased lamb birth weight, increased body weight gain, earlier onset of puberty, improved pregnancy rate of ewes and rams' libido. Those in coffee-based systems, however, have a less positive perception of sesbania feeding for improved performance and reproduction. They feed less quantity of sesbania less frequently to sheep compared to farmers in the wheat and teff cropping systems. This is due to relatively better availability of good quality feeds in their system. The majority of farmers in wheat systems (87%) and teff systems (85%) supplement sesbania during feed shortage seasons whereas most farmers in coffee systems (67%) have no specific season for supplementation and supplement according to availability. In all farming systems, farmers gave lowest priority to goats for sesbania feeding compared to sheep and cattle. Highest priority is given to sheep in the teff systems. Farmers follow two forms of feeding: wilted or freshly cut. They mention that wilted sesbania removes insects or fungi that might cause bloating or diarrhea when ingested and increases retention time of the feed in the animal. Farmers feeding freshly cut sesbania say they do this to increase intake of Sesbania and crop residues fed along with it.

(Oosting et al., 2011)

Planted forages: For many years efforts to promote the adoption of planted forages by smallholder livestock keepers in Ethiopia as a means of increasing feed availability, have borne scant return. However, if R&D agencies can use the participatory approaches illustrated by the CIAT SE Asia programme (cited above: Horne and Stür, 2003; Gabunada et al, 2007) and target the interventions at locations in which SR systems are, or have the potential to be, market-oriented, significant adoption of planted forages seems likely.

Farmers participating in the ELF field studies ranked planted forages, either as living fences or on soil conservation structures, as promising technologies for increasing feed biomass yield and quality (link to ELF field reports on wiki). A recent report, summarized in the Box above, suggests that *Sesbania sesban*, for example, can fit well in highland crop-livestock systems with small ruminants (Oosting et al., 2011).

Establishment and utilization of multi-purpose is knowledge intensive. For this reason, as shown elsewhere, careful evaluation of agro-ecological suitability and then participatory assessment of farm niches and participatory development of establishment and harvesting management practices, are required if planted forages are to achieve a significant role in improved SR feeding practices.

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Smart feeding: Natural grazing, crop residues and various by-products (including traditional brewers' grains) form the major feed components in SR production systems in Ethiopia (Solomon Gizaw et al, 2010). Seasonal variation in feed quantity and quality is a continuing challenge to smallholders' efforts to achieve a better return from their sheep and goats. Water scarcity may also sometimes limit animal performance. Changing the mix of feeds on offer has the potential to significantly improve productivity and profitability but it requires having estimates of the relative nutritive values and prices of available feeds, whether produced by the smallholder or available for purchase, and the prices of the target livestock products. Adugna Tolera (2007, 2008) describes the theory and gives practical examples for Ethiopia. A key objective for SR would be to explore improving live-weight gain by sheep and goats being prepared for sale to meet the demand at religious festivals, and another, to achieve the finish required by specific domestic and export markets.

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Smart feeding through better matching the use of feed resources to SR production objectives will be attainable if the systematic participatory analysis of value chains proposed in ELF, are applied. Capturing current prices of SR products and feeds and making that locally-relevant dataset easily accessible to public and private sector livestock advisers will be essential for the approach to work. It requires putting in place a system to routinely collect and collate the data (building upon the dataset compiled by ELF), and making it accessible through, for example, the electronic national market information system. Capacity building of livestock advisers in ration formulation, probably at zonal level will also be important. In turn the zonal specialists would train the woreda/district staff and their private sector counterparts. Given the important role of traders in SR marketing, their participation in providing advice on feeding practices should be explored.

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Two other aspects of smart feeding merit attention. Healthy SR perform better than unhealthy SR. Therefore, improved feeding strategies (e.g. better finishing rations) should address any disease that will limit responses to the better feeding. In SR gastro-intestinal parasites are the obvious example (Gray and Wagner, 2008). Others may be important and assessing the impact of possible disease x nutrition interactions should be integral to efforts to improve SR feeding strategies.

In the same area-specific mineral deficiencies may limit SR performance and, if addressed, can significantly improve flock productivity (Shinde and Sankhyan, 2011). Assessing the importance of any mineral deficiencies should be part of the SR smart feeding regime.

Conclusions

Experiences with R&D elsewhere that sought to develop improved small ruminant feeding strategies show that a farmer participatory, action-research based approach and drawing on a good understanding of the product value-chain, will be much more likely to succeed than previous efforts. Applying that approach in Ethiopia to address improvements to common property resources, crop residues, planted forages and ration formulation (smart feeding) has the potential to significantly improve SR meat production through better feeding.

Given the major contribution of crop residues and by-products to SR feeding, productive inter-institutional collaboration, e.g. between the crop and livestock sectors will be important. In the same way productive collaboration between public and private sector actors, e.g. traders in SR and feed, and public R&D staff, will be critical to success.

The challenges are substantial but with demand for SR meat rising, satisfying that demand represents an excellent opportunity for improving smallholder livelihoods through more efficient SR production.

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Appendix 1: Selected examples of research publications on improving feed resources for small ruminant meat production.

Insert Jane's Excel file here